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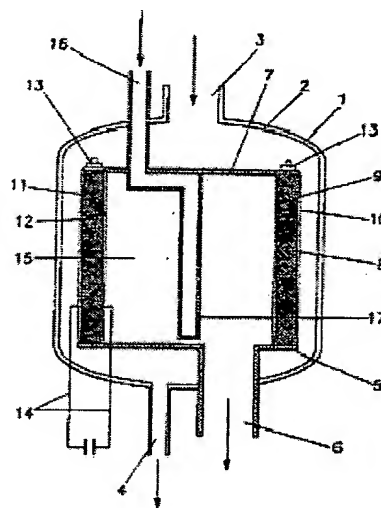
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(54) Device for recovery of solvents

(57) The invention relates to a device for the recovery of organic solvents which have a boiling point of below 250°C from the used-air flow of an operational unit, consisting of an adsorber with a ring-shaped electrically heatable fixed bed, filled with activated charcoal, which, for the adsorption of the solvent, is initially acted upon by the used-air flow and then, for the desorption or regeneration, by a vacuum and/or a gas. In order, during an electrical heating of the ring-shaped activated charcoal bed, to make possible a uniform temperature distribution in the activated charcoal bed and short regeneration times, to increase the degree of efficiency, to improve the clean-gas values and to reduce the danger of electric point discharges and of sparking, the outer and the inner casings (11, 12) of the ring-shaped fixed bed (8) consist of a lattice metal forming the electrodes.



The following details are taken from the documents submitted by the Applicant

Description

The invention relates to a device for the recovery of organic solvents which have a boiling point of below 250°C from the used-air flow of an operational unit, consisting of an adsorber with a ring-shaped electrically
5 heatable fixed bed, filled with activated charcoal, which, for the adsorption of the solvent, is initially acted upon by the used-air flow and then, for the desorption or regeneration, by a vacuum and/or a gas.

Adsorption processes are used for the separation and cleaning of gases in the most varied branches of industry if in particular small units with
10 low throughputs are necessary or if an adsorbable constituent present in small concentrations, for example a solvent, is to be separated off from a large, non-adsorbable carrier gas and thus recovered. Mostly used as adsorption agent is activated charcoal which is compressed from a powdery raw material accompanied by the addition of a binder for example into small rods which are
15 then poured into a vessel and form a so-called fixed bed. The fixed bed can have a ring-shaped cross-section, through which flows the gas to be cleaned, for example a used-air flow of an operational unit, from the inside to outside or vice versa, the solvents contained in the used-air flow settling due to the interactions between the molecules and capillary condensation effects on the
20 activated charcoal which forms the actual sorption surface. Various processes are known for regeneration of a loaded ring-shaped fixed bed formed from activated charcoal.

It is known to regenerate activated charcoal with an inert gas under normal pressure or a vacuum and to heat the activated charcoal with the inert
25 gas. This requires very long regeneration times as the inert gas possesses only a small heating capacity. As a consequence the activated charcoal beds have to be made relatively large. During such a regeneration the vessels and pipes are inevitably also heated, which brings with it an increased heat requirement and results in additional heat losses. As the areas of the
30 activated charcoal which are in contact with the vessel walls have a lower temperature than the centre of the activated charcoal bed, these areas are more poorly regenerated.

Another possibility for heating the activated charcoal during regeneration is to supply the activated charcoal with heated air. The

disadvantage here is that the degree of enrichment of the desorption air is relatively small and should only be so high that the explosion limit is not exceeded. Moreover however only those solvents can be treated which do not react with the oxygen of the air at the regeneration temperature under the catalytic action of the activated charcoal.

A further possibility of heating of activated charcoal is to pass heating coils through the activated charcoal bed. Here, too, long regeneration times, and thus large activated charcoal beds, are necessary. The temperature distribution in the activated charcoal bed is non-uniform and considerable heat losses occur. There are areas with different degrees of regeneration, because of the different temperatures.

Finally it is also known to heat the ring-shaped activated charcoal bed by electric current. To this end several electrodes are arranged in the activated charcoal bed which form the cathodes and anodes. Long regeneration times are likewise necessary due to the relatively low electric conductivity of the activated charcoal. However, another consequence of the low electric conductivity is that sparking can occur due to the electric voltages. Due to the design and the arrangement of the electrodes there is also a non-uniform temperature distribution in the activated charcoal bed, local overheating being able to occur. Due to this poor temperature distribution the achievable enrichments of the solvent in the desorption gas are relatively small and the achievable clean-gas values poor.

The object of the invention is therefore to create a device for recovery of organic solvents which have a boiling point of below 250°C from the used-air flow of an operational unit, which during an electrical heating of the ring-shaped activated charcoal bed makes possible a uniform temperature distribution in the activated charcoal bed and short regeneration times. The degree of efficiency is to be increased and the clean-gas values improved. Finally, the danger of electric point discharges and of sparking is to be reduced.

In order to achieve this object it is proposed according to the invention in the case of a device of the type mentioned at the start that the outer and inner casings of the ring-shaped fixed bed consist of a lattice metal forming the electrodes.

Through such a design a uniform temperature distribution is achieved in the activated charcoal bed and thus a shortening of the regeneration times. At the same time there is an increase in the degree of efficiency with an improvement of the clean-gas values. The danger of electric point discharges and of sparking is not insignificantly reduced.

Further features of a device according to the invention are disclosed in claims 2 to 7.

The invention is explained in more detail in the following using an embodiment represented in a drawing in a simplified way in the case of a so-called vacuum desorption. There are shown in

Fig. 1 a device according to the invention in section and

Fig. 2 a particular electric circuit of the device of Fig. 1 and

Fig. 3 another electric circuit of the device.

In Fig. 1 of the drawing a device is shown which serves to recover an organic solvent from the used-air flow of an operational unit. This device consists of at least two adsorbers 1 which are designed completely identical, for which reason only one adsorber 1 of which is represented in the drawing. The adsorber 1 firstly has a vessel 2 which is made for example from metal, measures having to be taken which electrically separate the vessel 2 from its fittings. The vessel 2 has an inlet 3 at the top, via which, as needed, used air or cooling air is introduced into the vessel 2. At its lower end the vessel 2 is provided with an discharge opening 4, which however forms part of the so-called regeneration cycle. In the vessel 2 is a bearing plate 5 made of electrically non-conductive material, which has a used-air line 6 leading outwards through the vessel 2 for the cleaned used air or for the heated cooling air. Arranged at a distance above the bearing plate 5 is a cover plate 7 likewise electrically non-conductive. A ring-shaped bed 8, developed between the bearing plate 5 and the cover plate 7, can have a annular or a polygonal, for example hexagonal, cross-section. This fixed bed 8 is delimited firstly by an inner supporting cage 9 and an outer supporting cage 10 which on one side are developed in load-bearing manner and have corresponding passages. On their casing surfaces facing each other the inner supporting cage 9 and the outer supporting cage 10 are fitted with a lattice metal 11, 12 known per se. Depending on the design of the lattice metal 11, 12 the inner

supporting cage 9 and the outer supporting cage 10 can also be formed exclusively from lattice metal 11, 12.

Activated charcoal known per se is poured into the ring-shaped space between the two supporting cages 9, 10 which, according to the invention, is
5 mixed as uniformly as possible with roughly 10 to 50 percentage by weight, advantageously with 30 percentage by weight, of a graphite grit with a grain size of 1 to 10 mm, advantageously from 3 to 5 mm. Indicated weights 13 can be arranged on the upper ring surface of the bed 8. A power source 14, for example an alternating current of 0 to 40 volts, is connected to the flat lattice
10 metal 11, 12. This alternating voltage is regulated according to the reference temperature of the activated charcoal bed 8.

A line 16 which forms part of the regeneration cycle opens out into the space delimited by the bearing plate 5, the cover plate 7 and the fixed bed 8. A gas distributor 17 which consists of a pipe with outlets is connected to the
15 inner end of the line 16.

In order to explain the mode of operation of the above-described device it is firstly assumed that the regeneration cycle is closed and that there is introduced into the vessel 2 via the inlet 3 used air which contains a solvent, for example ethyl acetate, in an amount of roughly 10 gram per m³. Due to the
20 structure of the adsorber 1 the used air is forced to flow from outside through the fixed bed 8 into the internal space. In the process, the solvent is in known manner adsorbed on the one hand by the attractive forces on the surface of the activated charcoal and on the other hand stored in the pores of the activated charcoal by capillary condensation. When the storage capacity of
25 the activated charcoal is exhausted and the maximum allowable solvent concentration of the clean air emerging from the opening 6 is reached, the second adsorber takes over the separating of the solvent, while the present adsorber 1 is switched to desorption. The signal for switching over can come e.g. from a concentration measurement device or a timer.

30 In the loaded adsorber 1 or the loaded fixed bed 8 the solvent must now be desorbed from the activated charcoal. This takes place in several steps. Firstly the vessel 2 is evacuated by a vacuum pump, not shown, via the line 10 to roughly 100 mbar. Then the vessel 2 is inertized to normal pressure by introduction of nitrogen via the line 16. Then the vessel 2 is again

evacuated via the line 16 to 100 mbar. As soon as this is finished the activated charcoal bed 8 is heated by applying an electric voltage, for example of 15 v and a current of 18,000 A, to a temperature of roughly 160°C. Any solvent vapours that form are separated off by downstream condensers, not represented. Now the nitrogen loaded with the solvent is passed by means of the vacuum pump already mentioned, in the so-called regeneration cycle through at least one condenser, not represented, in which the solvent condenses and drains off. The regeneration gas is again returned into the vessel via the line 16 by means of a pressure-reducing valve with a differential pressure of roughly 900 mbar.

If no more solvent condensate forms the heating of the regeneration or desorption cycle is stopped. The fixed bed 8 is now, starting from the inflow aperture 3, cooled again in a separate cooling cycle and then made capable of adsorption again for the adsorption of the solvent from the used air. To this end, the regeneration or desorption cycle is again closed and at the same time the inlet 3 for the used air and the outlet 6 for the cooling air is again opened. The already described procedure is now repeated.

With such an adsorber 1 the voltage drop in the bed 8 is roughly 14 volts. As the resistance is relatively small, relatively high streams flow, as already stated. High electric currents inevitably require large line cross-sections, which involves a not insignificant outlay. In order to avoid this outlay, the fixed bed 8 is divided into three sectors 8a, 8b, 8c and the outer casing 10 and the inner casing 9 are each formed from three parts 10a to 10c and 9a to 9c and are separated from each other by insulation plates 18. In addition, the parts 10a and 10b of the outer casing 10 and the parts 9b and 9c of the inner casing 9 are electrically connected to each other in each case via a bridge 19, 20. This gives the possibility of operating the adsorber 1 with a voltage of 45 v and a current of 6000 A with the same output, which requires much smaller line cross-sections.

In the embodiment of Fig. 3 the fixed bed is divided in the same way as in Fig. 2 into three sectors 8a, 8b, 8c or a multiple of "three". Also the outer and the inner casings 11, 12 consist of the same number of parts 11a, 11b, 11c and 12a, 12b, 12c, insulation plates 18 being likewise arranged here between the sectors 8a, 8b, 8c and the parts 11a, 11b, 11c and 12a, 12b, 12c.

The parts 11a, 11b, 11c of the outer casing 11 are now connected to the individual phases R, S, T of a three-phase current power source, while the parts 12a, 12b, 12c of the inner casing 12 are connected to the so-called neutral or middle conductor M. An inverse connection is also possible.

5 Advantageously, in this circuit, the parts 12a, 12b, 12c connected to the middle conductor M can again be formed in one piece.

By way of variation from the described embodiment, the regeneration or desorption can also take place under normal pressure. It is also possible, depending on the solvent to be removed and its concentration, to replace the
10 nitrogen, that is the inert gas, by air, which is then not operated in the cycle, but passed as solvent-enriched used air to a further used-gas treatment unit.

Patent claims

1. Device for the recovery of organic solvents which have a boiling point of below 250°C from the used-air flow of an operational unit, consisting of an adsorber with a ring-shaped electrically heatable fixed bed, filled with activated charcoal, which, for the adsorption of the solvent, is initially acted upon by the used-air flow and then, for the desorption or regeneration, by a vacuum and/or gas **characterized in that** the outer and inner casings (11, 12) of the ring-shaped fixed bed (8) consist of lattice metal forming the electrodes.
2. Device according to claim 1, characterized in that the ring-shaped fixed bed (8) has an annular cross-section.
3. Device according to claim 1, characterized in that the ring-shaped fixed bed (8) has a polygonal cross-section.
4. Device according to at least one of claims 1 to 3, characterized in that the upper end of the fixed bed (8) is closed off by a ring-shaped plate (7) that is able to be loaded with a weight (13).
5. Device according to at least one of claims 1 to 4, characterized in that the ring-shaped fixed bed (8) is divided into at least two sectors electrically insulated from each other (8a, 8b, 8c) and the outer and the inner casings (11, 12) forming the electrodes are likewise formed in each case from at least two parts electrically insulated from each other (11a, 11b, 11c, 12a, 12b, 12c) and these parts (11a, 11b, 11c, 12a, 12b, 12c) are electrically connected in series.
6. Device according to claim 5, characterized in that the ring-shaped fixed bed (8) is divided into three sectors electrically insulated from each other (8a, 8b, 8c) and the outer and the inner casings (11, 12) are formed in each case from three parts electrically insulated from each other (11a, 11b, 11c, 12a, 12b, 12c).
7. Device according to claim 5 or 6, characterized in that two neighbouring parts (11a, 11b, 11c, 12a, 12b, 12c) of the outer casing (11) and of the inner casing (12) are connected directly to each other via a bridge (19, 20).
8. Device according to at least one of claims 1 to 4, characterized in that the ring-shaped fixed bed (8) is divided into a number of sectors (8a, 8b, 8c)

divisible by three and the outer or the inner casing is formed from a number of parts (11a, 11b, 11c) likewise divisible by three and the parts (11a, 11b, 11c) are in each case connected to a phase (R, S, T) of a three-phase power voltage source, while the non-divided outer and inner casings (12) are
5 connected to the neutral or middle conductor (M).

2 pages of drawings

Fig. 1

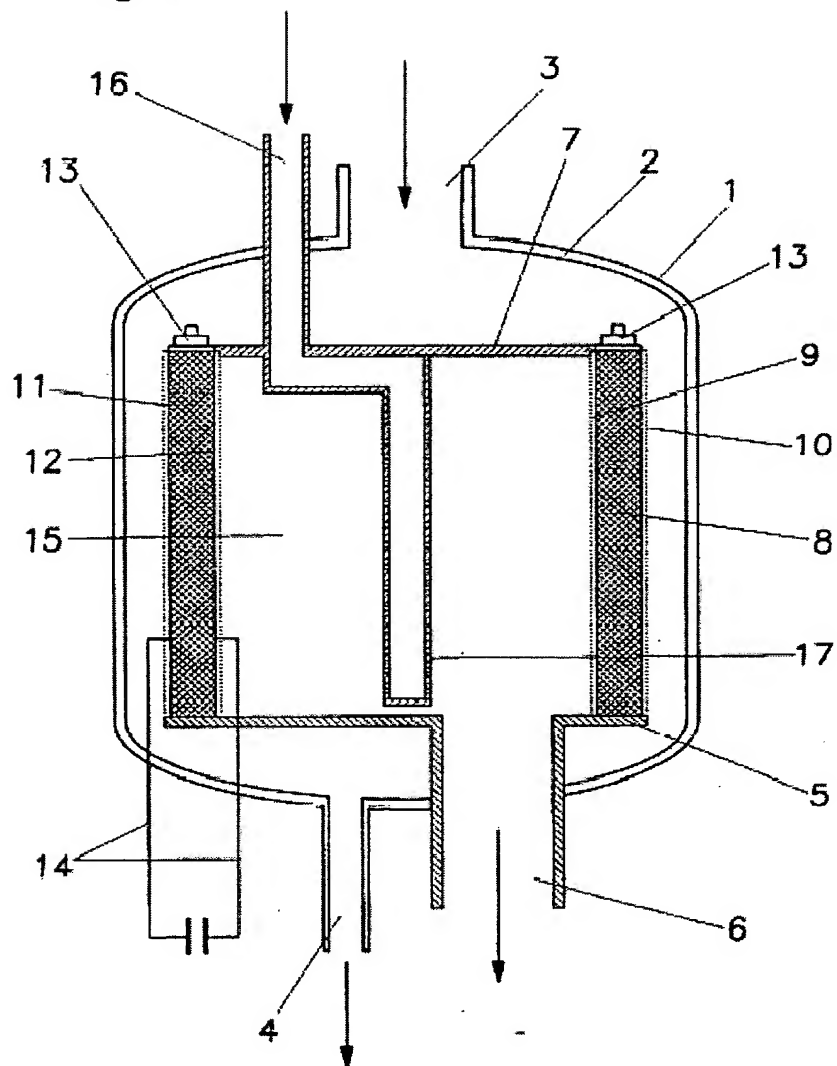


Fig. 2

Fig. 2 is a perspective view of a cylindrical device. The device consists of a top ring (8a) and a bottom ring (8b) connected by a central vertical structure (18). The top ring (8a) is connected to a terminal (11c). The bottom ring (8b) is connected to a terminal (19). The central vertical structure (18) is connected to a terminal (20). The top ring (8a) is also connected to a terminal (11a). The bottom ring (8b) is also connected to terminals (12a), (12b), and (12c). The central vertical structure (18) is also connected to a terminal (18).